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Stabilized Mud Blocks and Acoustic Insulation with Bamboo Dust

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***Abstract*—The construction industry is becoming more sustainable and energy-efficient building materials. The Stabilized Mud Blocks, on the other hand, offer an eco-friendly alternative to conventional bricks since it produces less carbon footprint and uses less energy in production. Bamboo dust, being the byproduct of bamboo processing, has been found to improve acoustic properties of construction materials. This paper discusses the incorporation of bamboo dust into Stabilized Mud Blocks and its effects on sound insulation, compressive strength, and overall performance. Results of experiments indicated that there was an improvement in the sound insulation due to bamboo dust, although with some compromise in the compressive strength. This study could help open the way to using bamboo dust as an alternative stabilizing agent in sustainable building materials.**

***Keywords*—Stabilized Mud Blocks (SMBs), Bamboo Dust, Sound Insulation, Sustainability, Acoustic Performance.**

I. Introduction

In recent years, there has been a growing shift in the construction industry toward more environmentally friendly and cost-effective building materials. This is due to the increasing demand for energy-efficient buildings, reduction of carbon emissions, and use of locally sourced materials. SMBs have become a promising alternative to the traditional building materials like fired bricks and concrete, due to their minimal environmental impact and energy-efficient production. These blocks are made by stabilizing local soil with additives, usually lime, cement, or other natural substances, to enhance their strength, water resistance, and durability. Although the thermal insulating properties of SMBs have been well recognized, the sound insulation has recently emerged as an important parameter for determining the suitability of such materials for modern construction, particularly in urban areas where noise pollution is a concern.

The by-product of dust of bamboo, a renewably grown, fast biomass crop that is non-depletable, is produced with very low environmental inputs and without much damage. Thus, it can add significant properties to SMBs while remaining cost-effective for using the waste byproducts from the bamboo processing processes. This research will address the impact of bamboo dust on the sound insulation characteristics of SMBs, while at the same time checking the influence on other mechanical properties, such as compressive strength and durability. Incorporation of bamboo dust in SMBs is hoped to result in a more sustainable building material that provides a better sound insulation characteristic and serves environmental sustainability.

II. Literature Review

Previous studies on stabilized mud blocks have focused more on stabilization techniques using lime, cement, and other locally available additives [1]. These stabilizers improve the compressive strength, water resistance, and durability of mud blocks. However, these stabilizers are not always environmentally friendly, which has prompted further research into natural alternatives.

Bamboo has been used for construction purposes because of its strength, renewability, and light weight. Recently, studies have been conducted to use bamboo fibers and bamboo dust as additives in the improvement of building material properties. The addition of bamboo fibers in cement-based composites has been found to improve mechanical strength and thermal properties [2][3]. For example, bamboo dust improves sound insulation in a range of building materials, which places it in promising additives for the enhancement of the acoustic properties of SMBs [4].

III. Methodology

The objective of this study is to evaluate the performance of Stabilized Mud Blocks (SMBs) incorporated with bamboo dust in terms of compressive strength, sound insulation, and durability. The methodology for the preparation and testing of the blocks is outlined below.

A. Material Collection and Preparation

Local soil was the base material selected for the preparation of SMBs. It was chosen for its suitability to form blocks and its natural composition. The soil was tested for grain size distribution, moisture content, and plasticity index. Another material used was the bamboo dust, which is the byproduct of the bamboo processing industry, collected

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from a local bamboo processing plant. Particle size distribution of the bamboo dust was analyzed using sieve analysis to ascertain that it had a fine texture that would be well mixed in the mud blocks.

Different percentages by weight of soil were used for addition of the bamboo dust to soil namely, 5%, 10%, 15%, and 20% to evaluate the effect of the additive on the properties of the mud blocks. A control sample was also prepared by using only soil and water, without adding bamboo dust for comparison. Water was slowly added to the soil-bamboo dust mixture to create a homogeneous, workable paste. The mix was then filled into standard dimension molds of 250 mm x 125 mm x 75 mm in size to make the blocks. The blocks were manually compacted to achieve proper density and consistency.

B. Curing

The blocks, after being moulded, were placed in a controlled environment and left to cure for a period of 28 days. Room temperature was adopted with relative humidity levels at 50-60%. During this period, periodic checks on uniformity of size and texture were performed on the blocks. The blocks were kept in a shaded area so that direct sunlight would not cause rapid drying and cracking. Once the blocks were cured, they were taken out of their moulds for testing.

C. Compressive Strength Testing

The compressive strength of the SMBs was determined based on the ASTM C39 standard for concrete [5]. Each block was tested in a hydraulic universal testing machine with a load capacity of 1000 kN. The blocks were placed between two flat platens, and the load was gradually applied until failure occurred. The maximum load at failure was recorded, and the compressive strength was calculated using the formula:

$$\sigma = F/A \quad (1)$$

Where:

σ = Compressive strength (MPa) F = Maximum load applied (N)

A = Cross-sectional area of the block (mm^2)

At least three blocks from each mix proportion (0%, 5%, 10%, 15%, and 20% bamboo dust) were tested to get an average compressive strength for each sample. These results were then compared against the control block to judge the effect of bamboo dust on the mechanical performance of the SMBs.

D. Sound and Insulation Testing

The blocks were tested for their sound insulation properties in an impedance tube method; this is a standardized measurement procedure for determining the sound absorption coefficient of materials. Here, the block was kept in a tube where, at one end, the sound source was used while at the other end, the sound intensity was measured using a microphone before and after passing through the block. The sound absorption coefficient α was calculated using the following formula:

$$\alpha = (Io - I) / Io \quad (2)$$

Where:

α = Sound absorption coefficient

Io = Incident sound intensity (W/m^2)

I = Transmitted sound intensity (W/m^2)

The experiment was conducted by testing blocks at various frequencies (250 Hz, 500 Hz, 1000 Hz, and 2000 Hz) to establish material's performance in a wide variety of sound frequencies. Results obtained were used to obtain the sound absorption and the transmission loss that were later compared with the control block and other percentages of the bamboo dust.

E. Durability Testing

To assess the durability of the bamboo dust-infused SMBs under real-world conditions, two types of tests were conducted: water absorption and freeze-thaw resistance tests.

1) Water Absorption Test : The water absorption test was performed by placing the blocks in water for 24 hours. The blocks were weighed both before and after immersion. The percentage of water absorbed was calculated using the formula as follows:

$$\text{Water Absorption (\%)} = [(W2 - W1) / W1] * 100 \quad (3)$$

Where:

1 = Initial weight of the block (g)

2 = Weight of the block after immersion (g)

2) Freeze and Thaw resistance: For freeze-thaw resistance testing, the blocks were submitted to freeze-thaw cycles to simulate exposure to harsh climatic conditions. The cycle consisted of freezing the blocks at -10°C for 24 hours and then thawing at room temperature for another 24 hours. The blocks underwent 25 cycles, and any visible cracks, deformation, or change in weight were recorded. The blocks' performance was compared through the calculation of percentage mass loss and visible cracks after the test.

IV. Experimental Results

A. Compressive Strength

Table 1 below shows the compressive strength results obtained for various percentages of bamboo dust. According to the data, up to 10% additions of bamboo dust resulted in enhanced compressive strength of SMBs. This may be due

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to the fine texture of bamboo dust that enhances bonding within the soil matrix. However, the compressive strength declines at a proportion greater than 10% bamboo dust. This is likely to be due to the excess dust creating voids in the material that weaken the overall structure.

TABLE I. COMPRESSIVE STRENGTH VS BAMBOO DUST PERCENTAGE

Bamboo Dust (%)	Compressive Strength (Mpa)
0	3.2
5	3.5
10	3.8
15	3.2
20	2.8

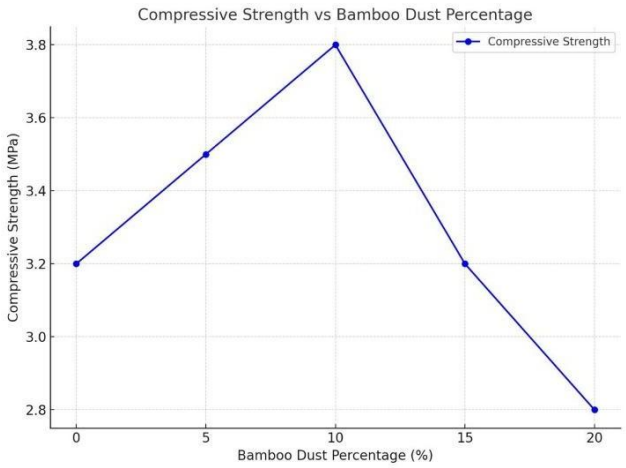

Fig. 1. Compressive Strength vs Bamboo Dust Percentage

B. *Sound Insulation*

The sound absorption coefficient results of the blocks are presented in Table 2. Significantly, bamboo dust drastically improved the sound insulation properties of the SMBs. The highest level of sound absorption was detected in the blocks with 10% bamboo dust, indicating an optimal acoustic performance with respect to material density. Higher levels of bamboo dust resulted in a decrease or slight levelling off in acoustic properties due to increased material density.

TABLE II. Sound Insulation Properties of SMBs with Bamboo Dust

Bamboo Dust (%)	Sound Absorption Coefficient (at 500 Hz)
0	0.21
5	0.34
10	0.48
15	0.42
20	0.38

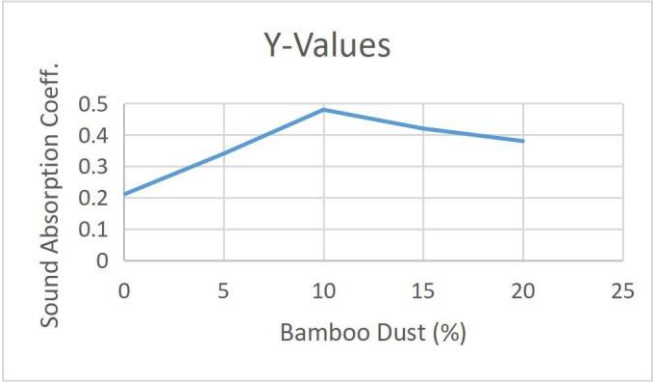

Fig. 2. Sound Absorption Coefficient vs Bamboo Dust Percentage

V. CONCLUSION

In particular, this study reveals potential in the use of a sustainable and efficient building material, Stabilized Mud Blocks (SMBs) enhanced with bamboo dust. The results show improved compressive strength and even further increase sound insulation properties of SMB by the addition of bamboo dust, with optimal performance reported at 10% by bamboo dust. This has resulted in a compressive strength of 3.8 MPa and shows the highest sound absorption coefficient of 0.48 at 500 Hz. However, higher bamboo dust content resulted in diminished strength and marginal acoustic improvements, underscoring the importance of maintaining an optimal balance.

The use of bamboo dust, which is a byproduct and renewable and environmentally friendly, reduces waste while meeting the requirements of sustainable construction. These blocks both enhance the mechanical properties as well as the acoustic, thus being an affordable and environmentally responsible substitute for traditional building materials. Future research could explore the durability under various environmental conditions and scale up the block for commercial applications.

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